



PROJECT PROGRESS REPORT

**PREPARED FOR THE ALASKA ENERGY AUTHORITY BY
THE ALASKA CENTER FOR ENERGY AND POWER**

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GRANT RECIPIENT: Alaska Center for Energy and Power
University of Alaska Fairbanks
814 Alumni Dr.
Fairbanks AK 99775-5910

EETF Round 2 Projects

Air Source Heat Pump, CCHRC

Data from the Wrangell and Dillingham air-to-air heat pumps as well as the Juneau air-to-water heat pump continue to automatically upload to the ACEP server on a daily basis. Below, the heat pump performances has been analyzed against outdoor temperatures.

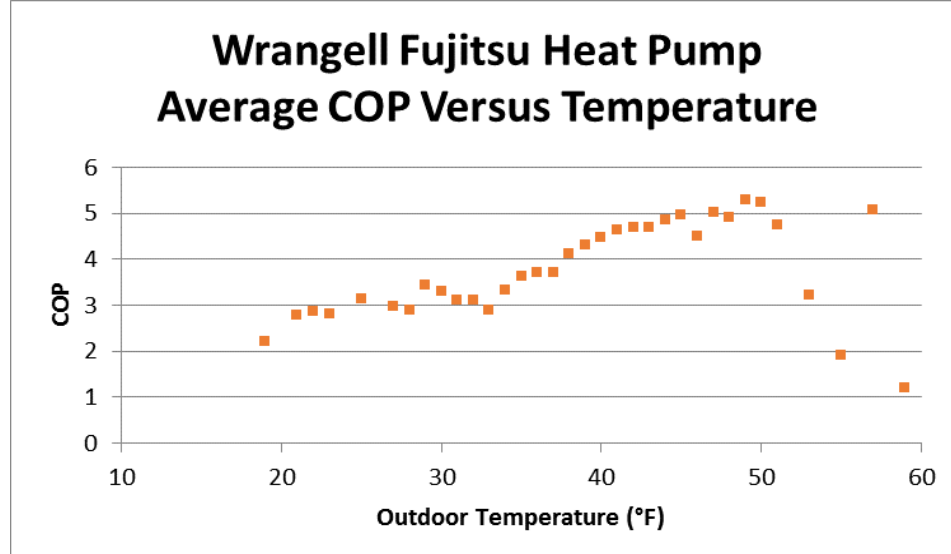
Wrangell, Alaska - Fujitsu Air Source Heat Pump:

The average heat pump coefficient of performance (COP) for the Wrangell Fujitsu is listed according to the average outdoor temperatures in Table 1. This data uses daily averages. The data was also analyzed at a five minute resolution, and results did not differ significantly. The data in the table and graph below shows that COP values remain above 3 when temperatures are above 25°F; however the COP values quickly drop as temperatures fall. Figure 1 also shows the COP values graphed according to the outside air temperatures. The low COP values above 50°F should be disregarded since there were likely other influencing factors.

Table 1: Wrangell air source heat pump performance data

Temps (°F)	Average COP	Average Daily kWh Electric Consumption	Average Outdoor Temperatures (°F)
<20	2.199198286	31.5	<20
20-24	2.817150525	18.2	20-24
25-29	3.105628312	14.4	25-29
30-34	3.150048096	14.2	30-34
35-39	3.895748275	9.8	35-39
40-44	4.668291734	8.3	40-44
45-49	4.935205679	6.5	45-49
50-54	8.496982948	3.7	50-54
55-59	2.723124728	1.9	55-59

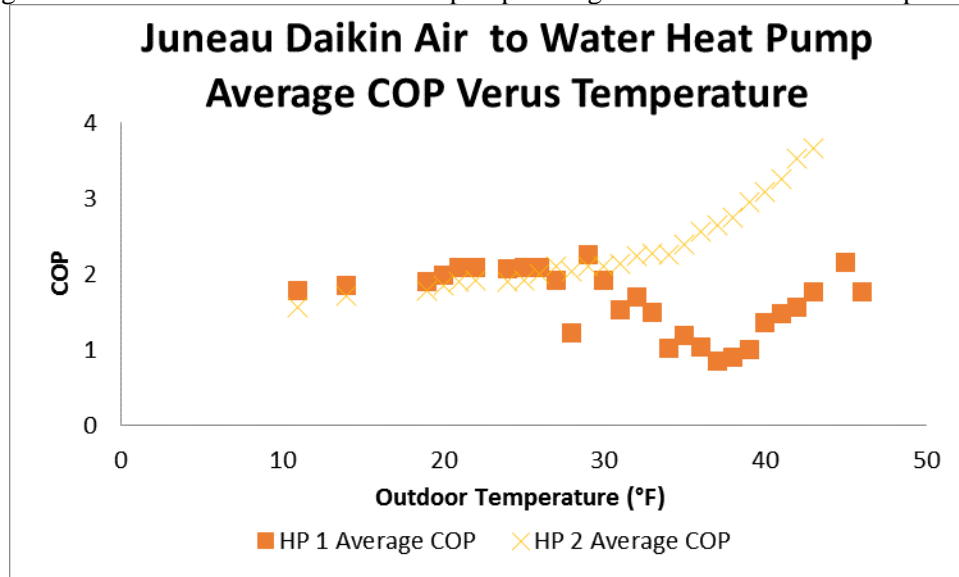
Figure 1: Average COP vs. outdoor temperature for Wrangell air source heat pump



Juneau, Alaska Daikin Air-to-Water Heat Pump:

The Juneau system uses two heat pumps. Heat pump HP-1 is dedicated to heating hot water, but when the outside temperature is below 30°F and there is no hot water demand, it operates with HP-2 for space heating. HP-2 supplies only space heating. Figure 2 shows the COP of both heat pumps at different outdoor temperatures. The results vary for the two heat pumps. HP-2, which supplies only space heating, operated at a COP of approximately 1.5 at 10°F, and the COP rose as the temperature rose. HP-1 operated at similar COPs to those of HP-2 between 10 °F and 30 °F; however, at temperatures above 30°F, when the heat pump was used for hot water only, the COP dropped.

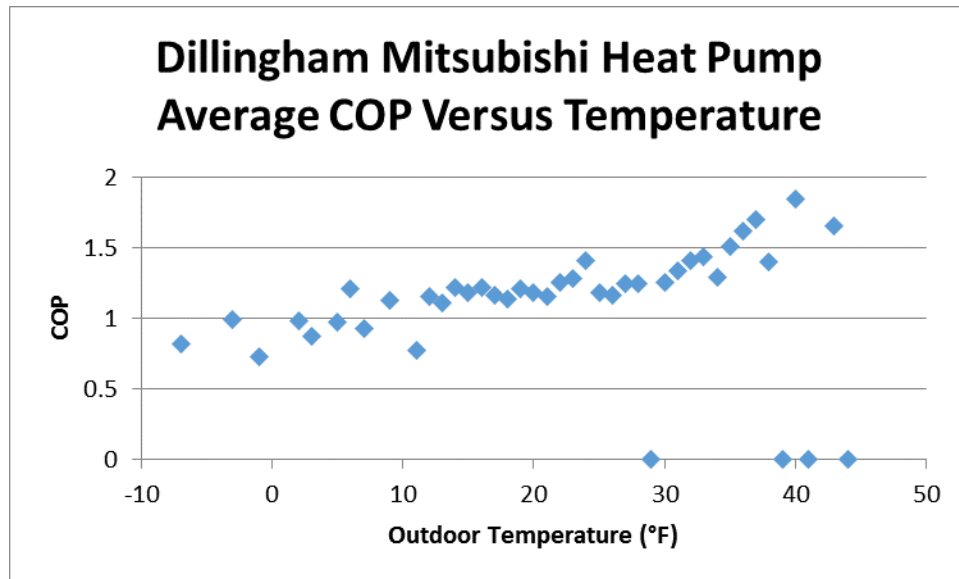
Figure 2: Juneau Daikin air source heat pump average COP versus outside temperature



Dillingham, Alaska Air Source Heat Pump:

The Dillingham Mitsubishi Heat Pump appears to be functioning at the lowest COP values of the three heat pumps for which detailed data is being collected. While Dillingham is the coldest location in which an air source heat pump is installed, the Dillingham heat pump is also a different brand. As shown in Figure 3, the data indicate the heat pump operates at a COP of about 1 when the temperature is 10°F. Colder temperatures cause lower COP values, and higher temperatures cause higher COP values. The cause for the lower than expected COP values is not entirely understood. Further detailed data analysis will take place next quarter once an entire winter's worth of data has been collected.

Figure 3: Dillingham Mitsubishi heat pump average COP versus outdoor temperature



The COPs of all three heat pumps will continue to be analyzed in future reporting. In addition, future analysis will focus on the heat pump time of day electrical use and the temperature versus electrical use. This analysis will further help to assess how well the heat pump matches with community loads and power availability.

Trans-Critical CO₂ Heat Pump, Alaska Sea Life Center

The Alaska Sea Life Center is still in the planning and procurement stages, and no infrastructure has been installed at this time and no data has been generated. ACEP continues to work with the Alaska Sea Life Center and monitor the status of this project

Multi-Stage Energy Storage System, Chugach Electric Association

Chugach reports that it is waiting to receive the grant agreement from AEA.

St. Paul Flywheel Demonstration, TDX

On February 4-5, 2015, ACEP engineer Chris Pike traveled to St. Paul Island with Alan Baldivieso and Josh Craft of AEA. AEA was performing a site visit for several projects on the island associated with REF and EETF funding. ACEP's main objective with the site visit was to review the TDX data collection strategy associated with the flywheel integration into the existing wind diesel system and to gain a better understanding of the overall working system.

The TDX wind diesel system has been isolated from the City of St. Paul grid for some time. TDX has three Vestas 225 kW turbines installed. One of those is generating electricity for a Petroleum Offshore Survey Support (POSS) camp, and two of the turbines are typically dedicated to selling power to the city. REF funding has enabled an intertie between the city grid and the TDX wind turbines as well as the construction of a waste heat loop that heats a number of city buildings near the power plant.

The EETF project has provided a Beacon flywheel that has been integrated into the TDX wind diesel system. Before the integration of the flywheel, the system had the capability to operate in diesel-off status based on an algorithm that determined the reliability of the wind during the previous ten-minute period. The flywheel has removed that ten-minute limit and allowed the system to operate in diesel-off status on a much more consistent basis.

The flywheel can provide seven minutes of energy storage for the POSS camp, and approximately five minutes are required to get a diesel generator up and running.

Notable information:

The City of St. Paul is complaining that its UPS systems around town continue to be damaged by poor power quality since the wind power has been integrated. TDX has been unable to measure this poor power quality on their system. TDX is interested in monitoring power quality of the town's power on the consumer side. It is also unclear if the cause is the wind, or if the power quality issues are independent of the wind.

ACEP engineer Chris Pike introduced Trident Seafoods efficiency manager Jeff Johnson to TDX employees. TDX is looking for customers to purchase more wind, and Trident is looking for ways to reduce their cost of power. Trident currently generates its own at a cost of approximately \$0.27/ kWh.

Figure 4: Jason Motyka of TDX explains the flywheel to members of AEA and Trident Seafoods. The Beacon flywheel is in the concrete structure in the foreground. The flywheel controls are in the black case (back left).



Figure 5: The Beacon controls.

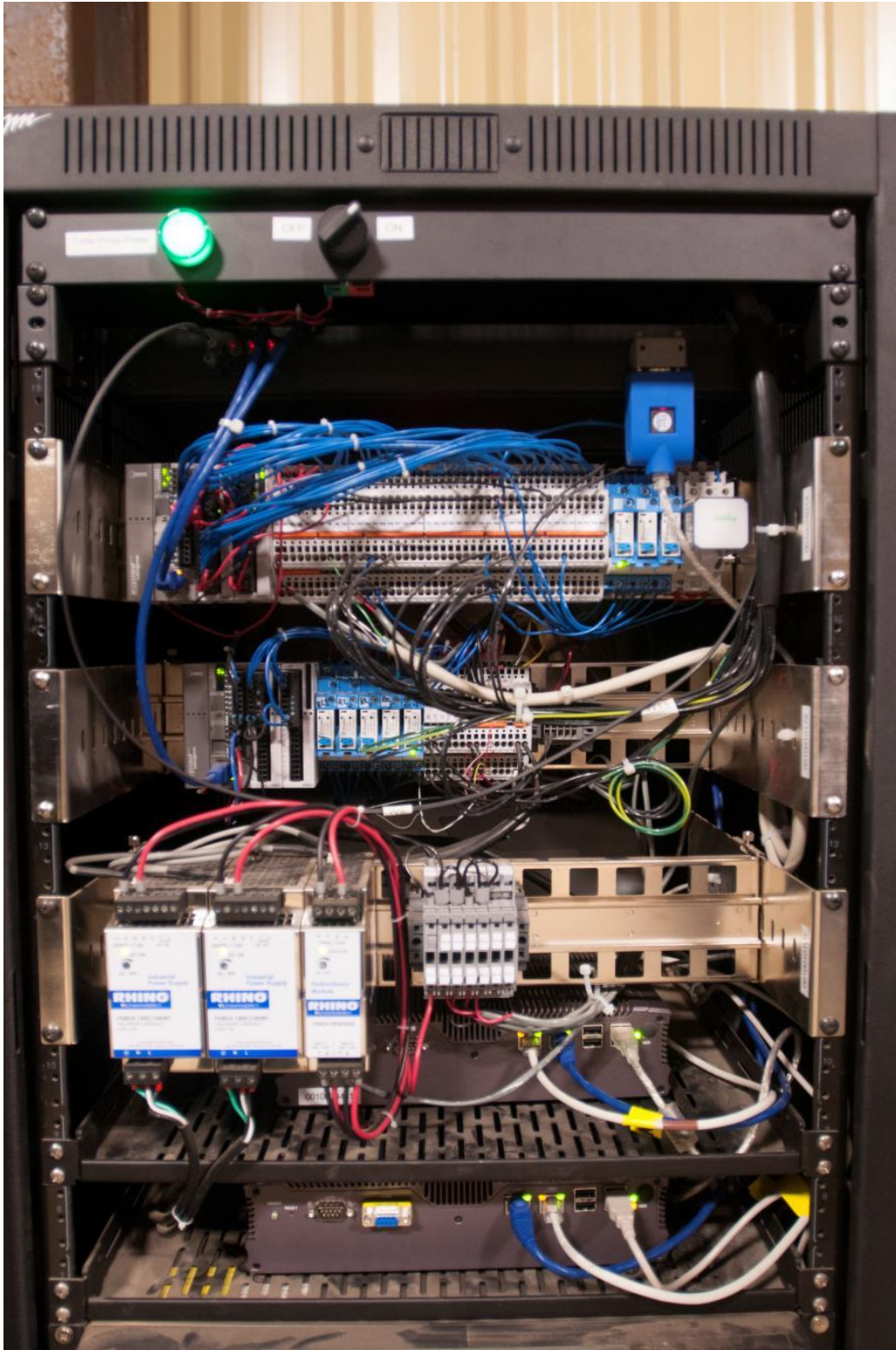


Figure 6: The TDX system controls and data collection. Data is stored on the Beckhoff computer shown in the bottom right. TDX officials say the computer has the capability of storing about 3 weeks of high resolution data.

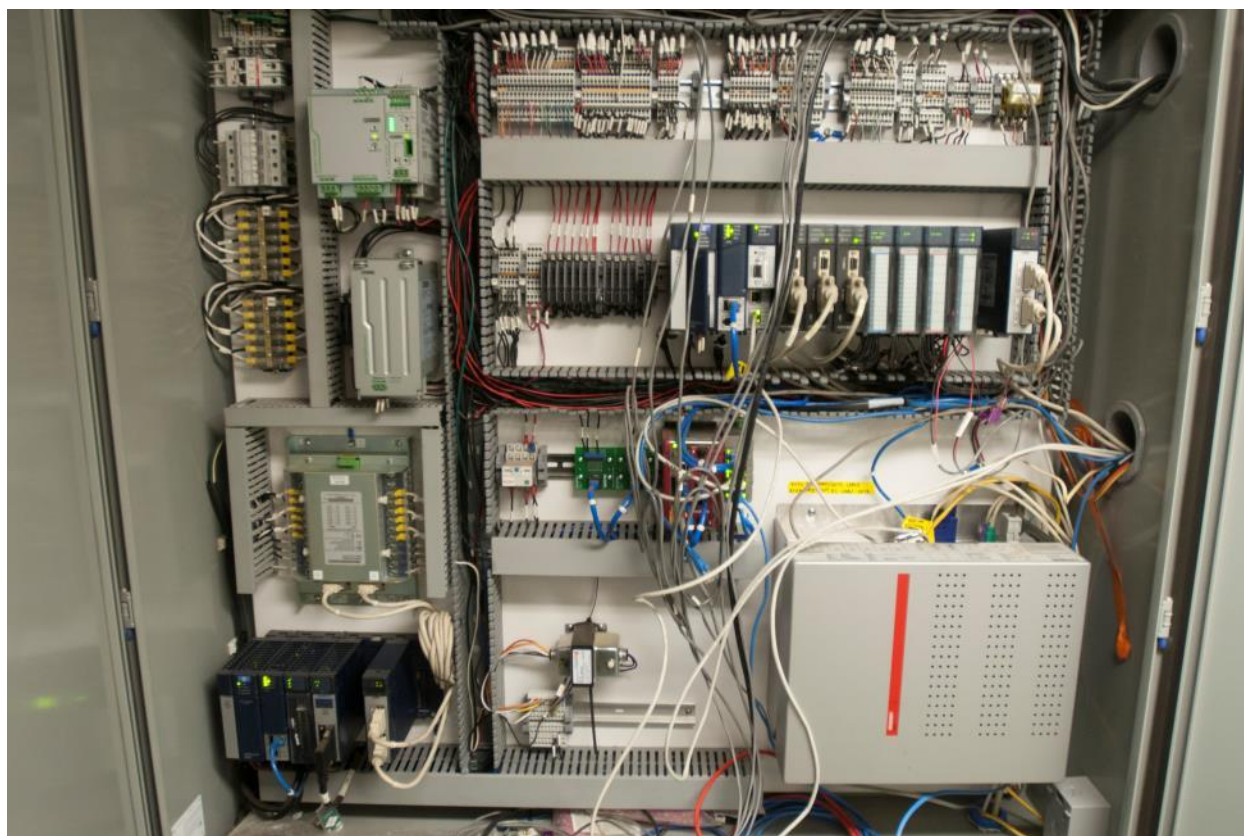


Figure 7: The Beckhoff computer where data is stored.

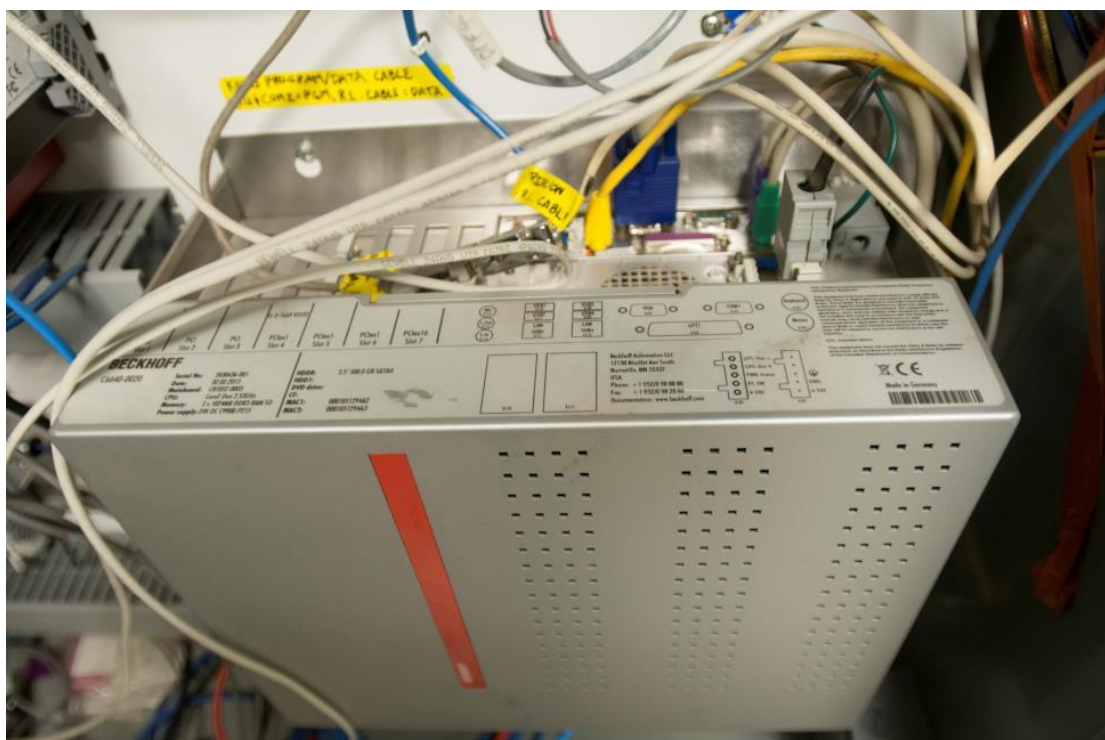


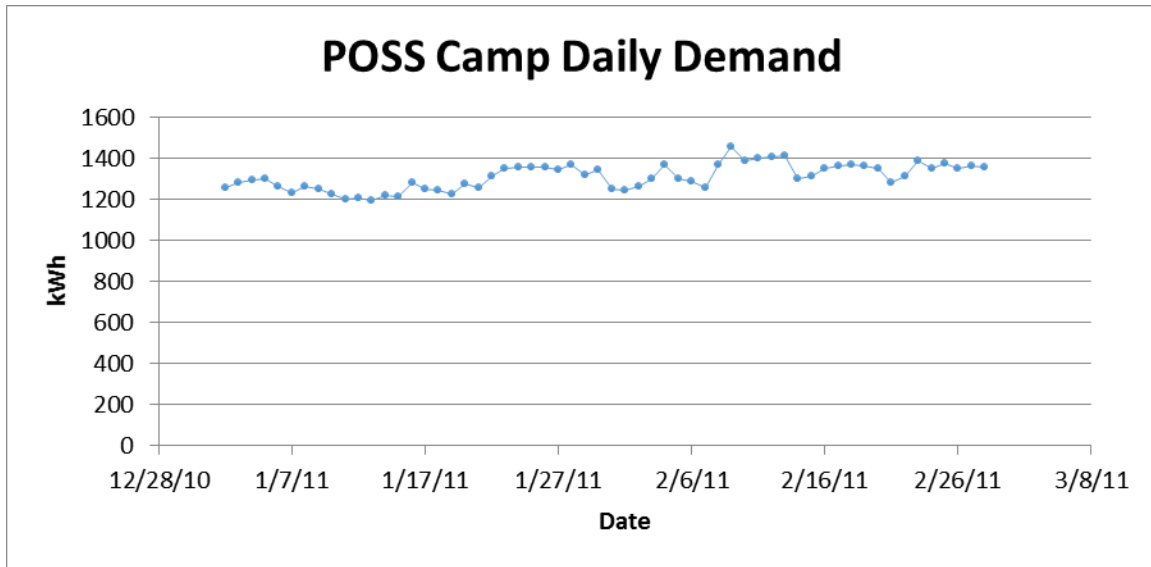
Figure 8: The hot water storage tank where excess wind energy is shunted. The thermal energy in this tank provides space heating for the entire POSS camp. It is programmed to reach maximum temperatures of 190 °F.



TDX logs its system continuously and provides daily ftp data transfer to ACEP. The sample rate is 0.5 Hz, and the logged parameters are extensive. This process is automated, and TDX has been transmitting data to ACEP since November 19th, 2014. There are currently over 4000 data files awaiting analysis.

For purposes of this update, data from January 1st, 2015 – February 28th, 2015 are used. Initial analysis revealed several anomalies in the data set that require investigation. In particular, units and/or scaling factors are missing. Nevertheless, during this two-month period, TDX supplied approximately 1300 kWh/day as shown in Figure 9 for a total of 75,976 kWh.

Figure 9: Power supplied by TDX for POSS from January 1-February 28, 2015.



During this timeframe the system ran in diesel-off mode for extended periods. At the end of each diesel-off event, the flywheel discharged during the transition to diesel power. Figure 10 shows one such transition. Of note is the frequency during the transition, as shown in Figure 11. Maximum deviation is less than 0.25 Hz.

ACEP intends to do thorough analysis of these data next quarter. In order to handle the huge number of files and data points, ACEP will import the data into National Instrument's DIADem or similar data analysis program.

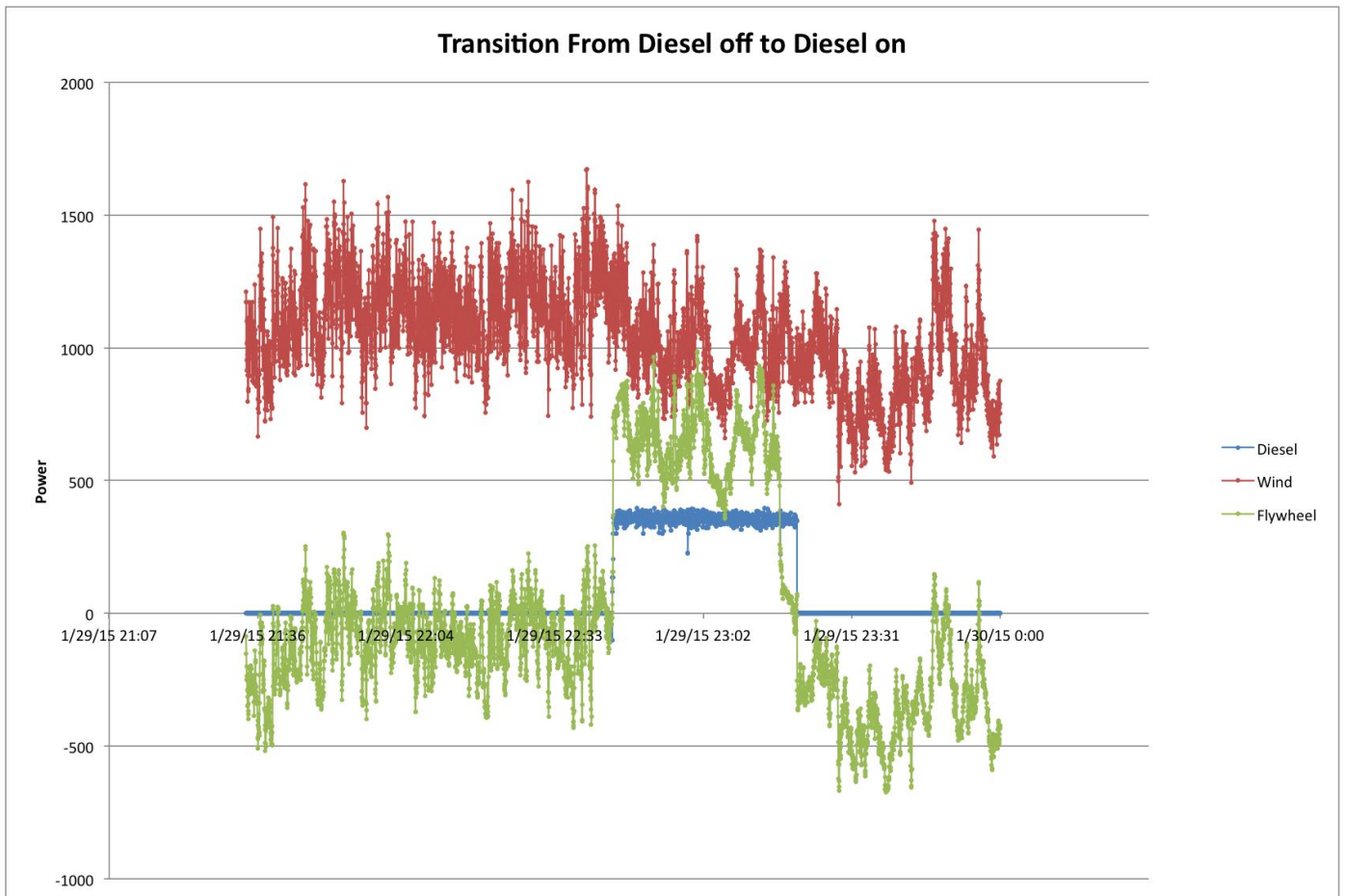


Figure 10: Power log during representative TDX diesel-off to diesel-on transition

Figure 11: Frequency log during representative TDX diesel-off to diesel-on transition

